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Smooth Muscle Endothelin B Receptors Regulate Blood Pressure but Not Vascular Function or Neointimal Remodeling

Eileen Miller, Alicja Czopek, Karolina M. Duthie, Nicholas S. Kirkby, Elisabeth E. Fransen van de Putte, Sibylle Christen, Robert A. Kimmitt, Rebecca Moorhouse, Raphael F.P. Castellan, Yuri V. Kotelevtsev, Rhoda E. Kuc, Anthony P. Davenport, Neeraj Dhaun, David J. Webb, Patrick W.F. Hadoke

Abstract—The role of smooth muscle endothelin$_B$ (ET$_B$) receptors in regulating vascular function, blood pressure (BP), and neointimal remodeling has not been established. Selective knockout mice were generated to address the hypothesis that loss of smooth muscle ET$_B$ receptors would reduce BP, alter vascular contractility, and inhibit neointimal remodeling. ET$_B$ receptors were selectively deleted from smooth muscle by crossing floxed ET$_B$ mice with those expressing cre-recombinase controlled by the transgelin promoter. Functional consequences of ET$_B$ deletion were assessed using myography. BP was measured by telemetry, and neointimal lesion formation induced by femoral artery injury. Lesion size and composition (day 28) were analyzed using optical projection tomography, histology, and immunohistochemistry. Selective deletion of ET$_B$ was confirmed by genotyping, autoradiography, polymerase chain reaction, and immunohistochemistry. ET$_B$-mediated contraction was reduced in trachea, but abolished from mesenteric veins, of knockout mice. Induction of ET$_B$-mediated contraction in mesenteric arteries was also abolished in these mice. Femoral artery function was unaltered, and baseline BP modestly elevated in smooth muscle ET$_B$ knockout compared with controls (+4.2±0.2 mm Hg; *P<0.0001), but salt-induced and ET$_B$-blockade–mediated hypertension were unaltered. Circulating endothelin-1 was not altered in knockout mice. ET$_B$-mediated contraction was not induced in femoral arteries by incubation in culture medium or lesion formation, and lesion size was not altered in smooth muscle ET$_B$ knockout mice. In the absence of other pathology, ET$_B$ receptors in vascular smooth muscle make a small but significant contribution to ET$_B$-dependent regulation of BP. These ET$_B$ receptors have no effect on vascular contraction or neointimal remodeling. (*Hypertension. 2017;69:275-285. DOI: 10.1161/HYPERTENSIONAHA.115.07031.) ● Online Data Supplement

Key Words: autoradiography ■ endothelin-1 ■ hypertension ■ neointima ■ vasoconstriction

Endothelin-1 (ET-1), released by vascular endothelial cell (EC) and inner medullary collecting duct cells (and other cells under pathological conditions), stimulates endothelin$_A$ (ET$_A$) and endothelin$_B$ (ET$_B$) receptor subtypes. They are present on vascular smooth muscle cells (VSMCs), predominantly mediating contraction and regulating blood pressure (BP). They also influence mitogenesis, generation of reactive oxygen species, and adhesion molecule expression. ET$_A$ receptors on leucocytes mediate cytokine release and cellular chemotaxis. Many of these processes contribute to vascular remodeling, and ET-1 clearly drives arterial lesion formation (including neointimal proliferation after injury). This can be inhibited by selective ET$_A$ antagonism.

Regulation of arterial function, BP, and arterial lesion formation by ET$_B$ receptors is likely to be more complex because they are expressed in EC, VSMC, and the kidney where they mediate physiologically antagonistic responses. ECET$_B$ receptors mediate production of vasodilator, antiproliferative, and anti-inflammatory molecules (eg, nitric oxide [NO])

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EC.\textsuperscript{13} VSMC ET\textsubscript{B} can mediate vascular contraction, similar to the ET\textsubscript{A} subtype,\textsuperscript{16} and may compensate for ET\textsubscript{A} receptor dysfunction.\textsuperscript{17} ET\textsubscript{B} upregulation in VSMC may mediate vascular constriction and proliferation in cardiovascular disease.\textsuperscript{18,19}

ET\textsubscript{B}-dependent regulation of BP is demonstrated by the sustained hypertension caused by ET\textsubscript{B} receptor antagonism in mice.\textsuperscript{20} The importance of receptor distribution in this response is indicated by increased BP after deletion of ET\textsubscript{B} receptors in the renal collecting duct\textsuperscript{21} but not after deletion of ECET\textsubscript{B}.\textsuperscript{22} The influence of VSMC ET\textsubscript{B} on BP has not been established but, given their potential to mediate vasoconstriction, deletion or antagonism of VSMC ET\textsubscript{B} would be predicted to reduce BP.

Despite the influence of ET-1 in vascular remodeling,\textsuperscript{23} the role of ET\textsubscript{B} is less clear. ET\textsubscript{B} activation in EC (NO release) and kidney (reduced BP) would be predicted to inhibit arterial remodeling, thus favoring selective ET\textsubscript{A} antagonist for reducing neointimal proliferation.\textsuperscript{9} Certainly, global deletion of ET\textsubscript{B} receptors in the renal collecting duct 21 but not after deletion of ET\textsubscript{B}.\textsuperscript{22} The influence of VSMC ET\textsubscript{B} on BP has not been established but, given their potential to mediate vasoconstriction, deletion or antagonism of VSMC ET\textsubscript{B} would be predicted to reduce BP.

Statistics

Results are mean±SEM, for n mice. Group sizes were chosen to detect 5%, 20%, and 20% differences in BP (n=7), lesion size (n=7), and maximum responses to vasoactive agents (n=6) with >90% power. Investigations were performed by operators blinded to treatment. Components of lesions were expressed as a percentage of the neointimal area. Analyses were performed with GraphPad Prism using Student t test, 1-way or 2-way ANOVA with a Tukey post hoc test, as indicated. Significance was assumed for \( P<0.05 \).

Detailed methods are in the online-only Data Supplement.

Results

Identification of SMET\textsubscript{B} KO

Genotyping for SM22cre, WT, and delta band alleles (Figure 1A) identified SMET\textsubscript{B} KO (positive for SM22cre, floxed, and delta band and negative for WT allele) and controls (SMET\textsubscript{B}\textsuperscript{f/f} cre-negative littermates; negative for WT allele, positive for floxed allele, and negative for SM22cre and delta band). SMC isolated from the aorta of SMET\textsubscript{B} KO mice expressed the cre, delta, and flox bands, whereas controls did not express the cre and the delta bands (Figure 1B).

Autoradiography (Figure 1C) identified ET\textsubscript{B} receptors in the gut lining, lung, and kidney. This signal was not diminished after SMET\textsubscript{B} deletion. ET\textsubscript{B} expression (real-time polymerase chain reaction) was not altered in the colon, heart, or gastrocnemius muscle of SMET\textsubscript{B} KO mice (Figure S1 in the online-only Data Supplement). Confocal imaging of immunofluorescence (Figure 1D) clearly showed ET\textsubscript{B} receptors localizing to the endothelium (von Willebrand factor positive) in SMET\textsubscript{B} KO coronary artery. ET\textsubscript{B} staining in medial SM remained at background levels. This confirms maintained ET\textsubscript{B} receptor expression in the endothelium of SMET\textsubscript{B} KO mice.

Functional Confirmation of SMET\textsubscript{B} KO

SMET\textsubscript{B} KO mice were healthy with normal body and organ weights (Table S1).

Sarafotoxin S6c (S6c)–mediated contraction in tracheas (which express ET\textsubscript{B} receptors on SM)\textsuperscript{22} from controls was abolished by incubation with the selective ET\textsubscript{B} antagonist A192621 (Figure 2A).\textsuperscript{21} In SMET\textsubscript{B} KO mice, S6c-mediated contraction was reduced (≈30%), but not abolished. The residual contraction was blocked by ET\textsubscript{B} antagonism. S6c-mediated contraction of mesenteric veins was abolished by selective deletion of SMET\textsubscript{B} (Figure 2B).

SMET\textsubscript{B} KO and BP

Control and SMET\textsubscript{B} KO mice demonstrated a clear diurnal rhythm in BP (Figure 3A). Mean 24-hour BP was higher in SMET\textsubscript{B} KO mice than in controls (107.1±0.3 versus 102.8±0.5 mm Hg; \( P<0.0001 \); Figure 3B). Systolic BP was not different between groups (123.5±0.6 versus 124.8±0.5 mm Hg; \( P=0.09 \); Figure 3C), but SMET\textsubscript{B} KO mice had an increased diastolic BP (98.2±0.3 versus 92.2±0.4 mm Hg; \( P<0.0001 \); Figure 3D). BP elevation occurred despite reduced heart rate (515±3 versus 538±5 bpm; \( P=0.004 \); Figure 3E). High salt increased BP in controls with a further increase induced by ET\textsubscript{B} antagonism (Figure 4A). These responses were similar in SMET\textsubscript{B} KO mice.
Figure 1. Selective endothelin_1 (ET_1) receptor deletion from smooth muscle. A. Mice were genotyped for (i) SM22cre (band at 500 bp), (ii) wild-type (band at 500 bp), and (iii) flox/delta (band at 1171 bp/delta band at 259 bp) alleles in ear clip DNA. (i) Samples 1 and 2 are cre-positive, (ii) sample 4 is positive for the wild-type allele; samples 3 and 5 are not, (iii) samples 7 and 8 are positive for both the flox (Continued)
and ET\textsubscript{b} antagonism increased plasma ET-1 to a similar extent in control-type and SMET\textsubscript{b} KO mice (Figure 4C).

**SMET\textsubscript{b} KO and Neointimal Remodeling**

Wire injury of the left femoral artery generated neointimal lesions (Figure 5A). Optical projection tomography demonstrated that SMET\textsubscript{b} KO altered neither the lesion volume (Figure 5B) nor cross-sectional narrowing (Figure 5C). Histological analysis showed a trend toward reduced cross-sectional narrowing in SMET\textsubscript{b} KO (Figure 5D). Ligation of the right femoral artery generated lesions with similar volume (Figure 5E) and maximal cross-sectional area (Figure 5F) in SMET\textsubscript{b} KO mice and control mice.

**SMET\textsubscript{b} KO and Vascular Reactivity**

In WT C57Bl/6J mice, EC removal from aortic rings abolished acetylcholine-mediated relaxation and enhanced the contractile response to phenylephrine but not to ET-1. EC removal from femoral arteries also abolished acetylcholine-mediated relaxation but had no effect on phenylephrine or ET-1 (Figure S3; Table S2). SMET\textsubscript{b} KO had no effect on contractile responses to phenylephrine or ET-1, or acetylcholine-mediated relaxation in femoral arteries (Figure S4; Table S3).

**Induction of ET\textsubscript{b}-Mediated Contraction in Isolated Mesenteric Arteries**

ET-1–mediated contraction in mesenteric arteries from WT C57Bl/6J mice was shifted to the right by mixed ETA/B, or selective ETA, antagonism, but not by ETB selective antagonism (Figure S5; Table S4). Unlike mesenteric veins (Figure 6A), mesenteric arteries freshly isolated from WT C57Bl/6J mice did not contract in response to S6c (Figure 6B). Incubation in culture medium (≤5 days) can induce ET\textsubscript{b}-mediated contraction in rat arteries. Incubation of C57Bl/6J mesenteric veins in culture medium had no effect on S6c-mediated contraction (Figure 6A). In mesenteric arteries, incubation in culture medium selectively increased the contractile response to ET-1 (Table S5). Strikingly, S6c-mediated contraction was induced in isolated mesenteric arteries after incubation in culture medium (Figure 6B; Table S5), a response abolished by selective ET\textsubscript{b}, or mixed ET\textsubscript{A/B}, antagonism, but not by selective ET\textsubscript{A} antagonism (Figure 6C; Table S6). Incubation of mesenteric arteries from SMET\textsubscript{b} KO mice in culture medium did not induce S6c-mediated contraction (Figure 6D).

**No Induction of ET\textsubscript{b}-Mediated Contraction in Femoral Arteries**

S6c-mediated contraction was variable in femoral arteries from WT C57Bl/6J mice: some contracted but others did not (Figure 6E). Neither incubation of femoral arteries in culture medium (24 hours; Figure 6F) nor lesion formation induced S6c-mediated contraction; femoral arteries isolated 28 days after ligation contracted in response to ET-1 (Figure 6G) but not to S6c (Figure 6H). Responses to acetylcholine, sodium...
nitroprusside, and phenylephrine were unaltered by lesion formation (Figure S6).

**Discussion**

Tissue-specific knockout mice were generated to address the hypothesis that selective deletion of ET\textsubscript{B} receptors from VSMC would impair arterial contraction, lower BP, and reduce neointimal lesion size. SMET\textsubscript{B} KO attenuated S6c-mediated vascular and tracheal contraction, without altering other functional responses, but produced a modest (≈4 mmHg) increase in BP. ET\textsubscript{B}-mediated contraction was not induced in femoral arteries after ligation, although injury-induced intimal lesion formation was unaffected by SMET\textsubscript{B} KO. Key findings are summarized (Figure S7) and compared with the ECET\textsubscript{B} KO (Table S7).

SMET\textsubscript{B} KO was based on our generation of ECET\textsubscript{B} KO,\textsuperscript{22} crossing mice expressing Cre-recombinase controlled by the SM-specific SM22 promoter\textsuperscript{25} with those bearing a floxed ET\textsubscript{B} gene.\textsuperscript{22} This strategy was used to produce mice with SM-selective ET\textsubscript{A} deletion,\textsuperscript{4} and renal collecting duct–selective
ET\textsubscript{B} deletion.\textsuperscript{21} It has also been used within our group to produce mice with SM-selective deletion of glucocorticoid receptor\textsuperscript{31} or 11\beta-hydroxysteroid dehydrogenase 1\textsuperscript{32} (with LacZ staining in Rosa26 reporter mice showing SM22\textsubscript{cre} expression in the blood vessels and heart but not in the brain, kidney, or adrenal gland). As with ECET\textsubscript{B} KO,\textsuperscript{22} SMET\textsubscript{B} KO mice were healthy. This contrasts with global ET\textsubscript{B} deletion, which causes coat spotting and death from megacolon,\textsuperscript{33} requiring transgenic ET\textsubscript{B} rescue in the enteric nervous system.\textsuperscript{34} Autoradiographic detection of ET\textsubscript{B} receptors in lungs of SMET\textsubscript{B} KO mice indicates maintained expression in EC (which was lost in ECET\textsubscript{B} KO).\textsuperscript{34} This was supported by colocalization of immunoreactivity for ET\textsubscript{B} with an EC marker (von Willebrand factor) in coronary arteries; absence of medial ET\textsubscript{B} staining was consistent with deletion from SMCs. Polymerase chain reaction confirmed that ET\textsubscript{B} had been deleted from aortic smooth muscle but not from heart, colon, or skeletal muscle (although direct evidence of ET\textsubscript{B} deletion from tracheal, mesenteric vein,
mesenteric, or femoral artery smooth muscle was not obtained using this technique). Functional investigations confirmed that SMETB-dependent responses were lost in the knockout, with the abolition of S6c-mediated contraction in mesenteric veins. Furthermore, induction of S6c-mediated contraction in mesenteric arteries incubated in culture medium (as in rat

Figure 5. Selective smooth muscle endothelinB (SMETB) deletion does not alter neointimal lesion formation. A, Wire injury–induced lesion formation in femoral arteries from control and SMETB knockout (KO) mice. Neointimal lesion volume (B) and maximal cross-sectional area (C) were similar in control and SMETB KO mice when measured by optical projection tomography. Similar results were obtained when maximal cross-sectional area was measured histologically (D). Volume (E) and maximal cross-sectional area (F) of lesions induced by ligation were similar in control and SMETB KO mice (optical projection tomography [OPT]). Data are mean±SEM (n=7). EEL indicates external elastic lamina; IEL, internal elastic lamina; L, lumen; and NI, neointima.
Figure 6. Impact of smooth muscle endothelinB (SMETB) receptors on vascular function. A, Sarafotoxin S6c (S6c)-induced contraction in mesenteric veins (n=6) was not increased by incubation for 1 (n=3) or 5 (n=1) d in culture. B, Freshly isolated mesenteric arteries (n=6) did not respond to S6c, but contractions were induced by incubation in culture medium for 1 (n=7) or 5 (n=3) *P<0.05, (Continued)
ETB receptors in peripheral ganglia can influence BP, 36 suggesting KO mice.4 Several possible explanations can be proposed. In contrast to controls (n=4), S6c-mediated, A192621 (100 nmol/L)-sensitive contraction was not induced in mesenteric arteries from SMETB knockout (KO) mice (n=4) by incubation in culture medium (24 h). **P<0.005, ***P<0.001 compared with antagonists. E, Contractile responses to S6c were unreliable in femoral arteries—some failed to contract, whereas others produced small contractions. P<0.05, ***P<0.005, ****P<0.001 compared with nonresponders. F, Incubation in culture did not induce S6c-mediated contraction in these arteries. Femoral arteries after ligation (28 d) contracted in response to endothelin-1 (G) but not to S6c (H). Data are means±SEM (n=3 to 6). ETA indicates endothelin_1, and KPSS, potassium physiological salt solution.

arteries15), was abolished by SMETB KO (although these functional changes do not necessarily confirm selective SMETB deletion). The failure to abolish S6c-induced contraction in trachea was unexpected and suggests either incomplete penetrance of SM22cre-mediated recombination or a role for ETB receptors in other cells (eg, epithelium) in mediating tracheal contraction. Detection of the delta band in some ear clip samples may suggest deletion of the floxed gene in germ cells, which is a possible limitation with these mice. However, our F/Cre0xF/Cre0 crosses did not produce piebald mice (which inevitably would occur if germ-line recombination takes place). Therefore, the delta band during genotyping can only be explained by the presence of SMC in the ear clip preparations.

Selective deletion of ETB from EC increased plasma ET-112 because of impaired clearance.14 In contrast, SMETB KO did not alter circulating ET-1, consistent with the proposal that ECETB predominantly mediate ET-1 clearance.

Transgenic and pharmacological approaches suggest ETB receptors regulate BP. Selective ETB receptor antagonism,20 global ETB deletion,10 and selective ETB deletion from the collecting duct21 all increased (≈10–13 mm Hg) BP. Furthermore, ETB receptors in peripheral ganglia can influence BP,56 suggesting that sympathetic activation accounts for ETB-induced hypertension.37 In contrast, BP was not elevated by ECETB KO.25 The small (≈4 mm Hg) increase in BP, which persisted in SMETB KO mice despite reduced heart rate, suggests that loss of SMETB contributes to the increased BP induced by systemic ETB antagonism25 or global ETB deletion.6 However, it requires rejection of our hypothesis that ETB-mediated vascular contraction contributes to BP elevation. Indeed, our data support a role for extravascular ETB (eg, in the kidney or peripheral ganglia) in regulating BP. This is supported by the demonstration that, as in ECETB KO,25 salt-induced and ETB antagonist–induced elevations of BP are unaltered by SMETB KO. The mechanism underlying increased BP after SMETB KO is not apparent but is unlikely to be a consequence of cre overexpression in SM because this did not alter baseline BP in SMETA KO mice.4 Several possible explanations can be proposed. First, ETB in VSMC may contribute to the clearance of ET-1 from tissue where it is preferentially secreted by EC, and where it acts. Therefore, SMETB KO may cause ETB accumulation in the vascular wall, thus increasing ET-1–mediated vasoconstriction. Second, loss of SMETB may upregulate ETA-mediated contraction. Third, SMETB in the kidney may influence sodium homeostasis. Because SM22 may be expressed in perivascular fat precursors,66 loss of ETB from perivascular fat may have caused developmental changes in vascular function that also contribute to elevated BP, but this has not been established. It is also not clear why basal diastolic blood pressure is selectively increased in the SMETB KO, but this would be worthy of future investigation.

Increased BP in SMETB KO mice could not be attributed to vascular dysfunction as, with the exception of responses to S6c, we found no evidence of impaired arterial relaxation or contraction. Weak ETB-mediated contraction in arteries is consistent with studies in rats.38 Preliminary investigations (unpublished data) indicated that S6c-induction of freshly isolated murine arteries (femoral, mesenteric, and carotid) was not increased by NO synthase inhibition or by removal of the endothelium. These results indicate that we are not missing an ETB-mediated contraction that has been obscured by ETB-mediated relaxation. Induction of ETB-mediated contraction after incubation has been attributed to transcriptional regulation and MEK-ERK1/2 signaling.22,58 Abolition of this response in mesenteric arteries from SMETB KO mice indicated that they lack both functional arterial ETB receptors and the means to generate new receptors in this tissue.

ETB upregulation in SMC, mediating vasoconstriction and proliferation in cardiovascular disease,18,19 might explain studies reporting similar benefit from mixed ETA/B and selective ETB antagonism in reducing lesion formation8,9,30 (despite the protective roles of ETB in several tissues, eg, EC and kidney). However, the effectiveness of mixed ETA/B and selective ETB antagonism is likely to depend on the balance of ETB receptor activity in EC and VSMC of an affected artery. Transient upregulation of ETB and ETA receptors has been demonstrated in arterial lesions.41 If these ETB receptors contribute to lesion formation, then ETB antagonism would be desirable. There was, however, no evidence of induced ETB-mediated contraction in mouse femoral arteries after ligation. Similar investigations could not be performed after wire injury because these vessels fail to contract ex vivo. It remains possible that ETB upregulation occurs in other (eg, carotid) arteries.

Neointimal lesion formation is increased in rescued global ETB knockout mice10 and in (spotted lethal) rats with global deletion of ETB.7,24 consistent an antiproliferative role for ETB receptors. This is supported by demonstrations that ETB receptor antagonism increases lesion size,9,24 with the suggestion that this is because of impaired ETB-mediated release of NO from EC. Indeed, increased lesion formation in mice with global ETB deletion was partly attributed to impaired EC–derived NO release.9 In contrast, selective ECETB deletion inhibited ETB-mediated relaxation22 but had no effect on arterial lesion formation.57 These results suggest, therefore, that the protective role of ETB receptors is played by non-ECETB receptors. The demonstration here that deletion of ETB from the SMC does not alter lesion size indicates that, as with the receptors in EC, ETB in SMC do not influence neointimal remodeling. This implicates nonvascular ETB receptors, for
example, in monocyte-derived macrophages, in the regulation of neointimal proliferation and atherosclerosis.\textsuperscript{42}

In conclusion, we have demonstrated that selective ET\textsubscript{B} receptors in SMC may contribute modestly to regulation of BP but have little influence on vascular contraction or neointimal proliferation. These data suggest that any detrimental role of SMETB is minor (at least during normal physiology), and, therefore, that selective ET\textsubscript{A} receptor antagonists (which preserve protective EC/renal ET\textsubscript{B} signaling) should be preferred to mixed ET\textsubscript{A/B} antagonists for treatment of vascular disease.

**Perspectives**

Generation of mice with selective deletion of ET\textsubscript{A} from SMC indicates that these receptors contribute to the increased BP induced by ET\textsubscript{B} receptor antagonism but do not regulate arterial function or the fibroproliferative response to acute arterial injury. It would be interesting to determine whether ET\textsubscript{B} in SMCs influence other cardiovascular diseases (eg, diabetic complications). Whether the data generated in these animals are replicated in mice with cardiovascular disease (eg, atherosclerosis), or in man, remains to be established. However, these results support the proposal that selective ET\textsubscript{A} receptor antagonists may have advantages over mixed ET\textsubscript{A/B} antagonists for combating elevated BP or restenosis after revascularization.

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**Disclosures**

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What Is New?

- This study describes newly generated mice with selective endothelin\(_B\) receptor deletion from smooth muscle. This was used to clarify the influence of smooth muscle ET\(_B\) receptors on (1) blood pressure, (2) arterial and venous contraction, and (3) arterial remodeling following injury.

What Is Relevant?

- Generation of the knockout was necessary because ET\(_B\) receptors in vascular endothelial and smooth muscle cells cannot be distinguished pharmacologically. This work shows that ET\(_B\) receptors in smooth muscle have little influence on arterial function or neointimal remodeling but have a small suppressive effect on diastolic blood pressure. This is consistent with the proposal that selective endothelin\(_B\), ET\(_A\) antagonism would be preferable to mixed ET\(_A/ET\(_B\) antagonism for inhibiting arterial remodeling.

Novelty and Significance

- Selective smooth muscle ET\(_B\) deletion indicated that these receptors play a minor role in regulation of BP but do not affect vascular function or remodeling. This suggests that, beyond endothelial cell ET\(_B\), ET\(_B\)-dependent regulation of these processes is mediated by receptors in extravascular cells (eg, renal cortical ducts).

References

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Supplementary Information

Eileen Miller¹, Alicja Czopek¹, Karolina M Duthie¹, Nicholas S Kirkby¹, Elisabeth E Fransen van de Putte¹, Sibylle Christen², Robert A. Kimmitt¹, Rebecca Moorhouse, Raphael FP Castellan¹, Yuri V Kotelevtsev³, Rhoda E Kuc⁴, Anthony P Davenport⁴, Neeraj Dhaun¹, David J Webb¹ and Patrick WF Hadoke¹

¹Centre for Cardiovascular Science, University of Edinburgh, Edinburgh, UK, ²University of Basel, Switzerland, Stem Cell Genome Modification Laboratory, ³Skolkovo Institute of Science and Technology Novaya St. 100, 143025, Skolkovo, Russian Federation, ⁴Division of Experimental Medicine & Immunotherapeutics (EMIT), Addenbrooke's Hospital, Hills Road, Cambridge CB2 2QQ.

Short Title: ETB deletion, BP and arterial remodelling
Animals
Mice with VSMC selective deletion of ET_{B} receptors were generated based on a strategy described previously to produce EC ETB KO mice\(^1\). Homozygous (Flox/Flox) ET_{B} mice (background: 50% 129/Ola and 50% BKW) were crossed with SM22-Cre transgenic mice and backcrossed to C57Bl/6J for 4-6 generations. As for previous studies\(^1,2\) floxed, Cre-negative littermates (ET_{B}^{f/f}) were used as experimental controls for SM-specific ET_{B} deficient mice (SM ET_{B} KO). Genotyping to identify wild type and recombined alleles was performed by PCR\(^1\) and the SM22-Cre transgene was detected as described\(^3\). All mice were given free access to tap water and standard mouse chow. Mice were housed according to United Kingdom Home Office recommendations at 22°C with 12-hour diurnal light/dark cycles. All procedures were performed under the provisions of the Animals Scientific Procedures Act (1986) and with the approval of the local ethics committee.

 Autoradiography
After euthanasia, SM ET_{B} KO mice and controls (n=3/group) were rapidly frozen at -70°C, torsos were mounted in a cryostat and consecutive 30μm longitudinal sections were cut to encompass the major thoracic and abdominal organs. Sections were thaw-mounted onto gelatin-coated slides\(^4\) and ligand binding assays performed as described\(^5\). Briefly, consecutive sections were incubated with 0.25nM of the ETA selective ligand [^{125}I]PD151242 or 0.25nM of the ETB selective ligand [^{125}I]BQ2030 (Amersham Bioscience, GE Healthcare, UK). Non-specific binding was determined by co-incubating adjacent sections with the ligand and corresponding excess unlabelled peptide. Slides with calibrated standards were exposed to Kodak MR-1 autoradiography film for 4 days before being developed.

 Immunohistochemistry
Immunohistochemical identification of ET_{B} receptors was performed as previously described\(^6\). Site directed antisera were raised in rabbits to the sequence ET_{B}(302-313), as described\(^7\). Briefly, whole body tissue sections (15 μm) were dried overnight at room temperature and fixed in ice-cold acetone for 10 minutes. Three knock-out and three control mice were examined.

Slides were incubated with 5% non-immunised donkey serum (DS) in phosphate-buffered saline (PBS) for 1 hour at room temperature to block non-specific protein interactions and then incubated overnight at 4°C with primary rabbit anti-ET_{B} (1:50) antiserum and primary goat anti-von Willebrand factor (1:50) PBS/0.1% Tween-20/3% DS. Slides were then washed (3×5 minutes) in cold 1% PBS/0.1% Tween-20 before incubation for 1 hour at room temperature with Alexa Fluor 488 conjugated donkey anti-rabbit (1:200), Alexa Fluor 568 conjugated donkey anti-goat (1:100) secondary antibodies and Hoechst (1:100) diluted in 1% PBS/0.1% Tween-20/3% DS. Tissue sections were washed again (3×5 minutes) in cold 1% PBS/0.1% Tween-20 and mounted with ProLong Gold (Invitrogen). Confocal imaging was performed using a Leica TCS-NT-UV confocal laser-scanning microscope (Leica Microsystems, Heidelberg, Germany).

Ex vivo analysis of ET_{B}-mediated contraction
Functional analyses were performed using isolated mouse trachea, aorta, femoral arteries, and 1st order mesenteric arteries and veins, as described\(^8\). The endothelium was removed from some aortic rings by rubbing the luminal surface with a wire. Some arteries and veins were incubated in serum-free medium (DMEM) for 1-5 days before functional analysis to induce ET_{B}-mediated contraction, after the method of Adner et al.\(^9\). Briefly, rings (~2mm in length) of trachea, femoral artery, or mesenteric artery or vein were suspended on two intraluminal
40 µm tungsten wires in a myograph (model 610M Multi-myograph; JP Trading, Aarhus, Denmark) chamber. These rings were equilibrated at their optimum resting force (trachea 2mN; aorta 7.36mN; femoral artery, 8mN; mesenteric artery 3mN; mesenteric vein, 1mN) in physiological salt solution (PSS; 119 mM NaCl, 14.9 mM NaHCO₃, 4.7 mM KCl, 1.18 mM KH₂PO₄, 1.17 mM MgSO₄, 1.6 mM CaCl₂, 0.026 mM EDTA, 5.5 mM glucose), aerated (95% O₂, 5% CO₂) and maintained at 37°C. Each ring was then exposed to a high potassium (125mM) PSS (KPSS). Cumulative concentration-response curves were obtained to phenylephrine (PE, 1x10⁻⁹-3x10⁻³M), ET-1 (1x10⁻¹¹-3x10⁻⁵M), acetylcholine (1x10⁻⁹-3x10⁻³M) or sarafotoxin 6c (S6c; 1x10⁻¹¹-3x10⁻⁵M), as required. Some rings were incubated with an ETA antagonist (BQ123; 100nM), an ETB antagonist (A192621; 100nM) or a mixture of the two antagonists 20 min before acquiring cumulative concentration-response curves. All responses were measured and recorded with Powerlab software.

Measurement of BP
Male SM ETB KO mice and age-matched controls (n=8/group) were caged singly and maintained on standard mouse chow (7 days) before measurement of BP and heart rate using telemetry, as described previously¹. Briefly, under isoflurane anesthesia, a telemetry catheter was inserted into the left carotid artery and the transmitter device (Data Sciences) secured in the left flank. Mice were allowed to recover and were maintained on standard chow (7 days), high (7.6%) salt diet (7 days), then high salt plus ETB antagonist (SB192621; 30/mg/kg/day in drinking water, 7 days). Systolic and diastolic BP and heart rate were recorded in unrestrained mice (for 5 min every 30 min) as described previously¹ and analyzed using the Powerlab data acquisition system. Average blood pressures over each 5 min period (48 measurements/day) were used to calculate the 24 h average BP.

Femoral artery injury
Intra-luminal injury was performed as described². Briefly, under inhaled isoflurane anaesthesia (induction 5%, maintenance 2-3%) a 0.014” diameter straight-sprung angioplasty guide wire was advanced ~1.5cm proximally into the isolated femoral artery through an arteriotomy in the popliteal branch. After withdrawal, the popliteal branch was ligated to allow re-perfusion of the injured femoral artery. Non-denuding injury was achieved by ligation of the right femoral artery at the femero-popliteal bifurcation². Peri-operative analgesia was provided by administration of buprenorphine (0.05mg/kg buprenorphine s.c.; Alstoe Animal Health, UK). Mice were then allowed to recover (28 days) to allow lesion development.

Perfusion fixation
After the recovery period mice were killed by perfusion fixation. Under terminal anaesthesia (sodium pentobarbital, Ceva Animal Health, UK, 60 mg/kg; i.p.), thoracotomy and transverse sternotomy were performed to allow introduction of a 23-gauge needle into the left ventricle. Phosphate buffered saline containing heparin (Leo Laboratories, UK, 10 U/ml) was administered (6 ml/min) via the left ventricle and an incision was made in the right ventricle to allow perfusate to wash through. Once blood was washed out, 10% neutral buffered formalin (Sigma, UK) was perfused until adequate fixation occurred (indicated by the development of rigidity of the body). Following perfusion fixation, femoral arteries, liver, heart and kidneys were removed. Organs were weighed and all tissues were left in formalin for a further 48h before processing to paraffin for histological assessment.

Optical projection tomography
Non-destructive 3-dimensional assessment of lesions was performed using optical projection
tomography (OPT), as described10,11. Briefly, vessels were embedded in agarose and optically
cleared in benzyl alcohol/ benzyl benzoate. Intrinsic fluorescent emission was imaged
(excitation filter: 425/40 nm; emission filter: 475 nm low pass) using a Bioptonics 3001
tomograph. Data were reconstructed by filtered back projection using NRecon software
(Skyscan, Belgium) and volumetric measurements generated by semi-automated tracing of
the internal elastic lamina and the neointima distinguished from the lumen using a grey level
threshold.

**Histological assessment of neointimal lesions**
Sections (4 µm) were cut from paraffin-embedded femoral arteries at 80 µm intervals with a
Leitz 1512 microtome (Leica microsystems, Germany), and mounted onto Superfrost glass
slides. Every tenth slide was selected for staining (Shandon Varistain Gemini automated slide
stainer) with United States Trichrome, as described12. Images were taken using an Axioskop
KS300 stage microscope (Carl Zeiss Inc., UK) and a CCD camera (photometrics USA) with a
liquid crystal filter (MicroColour, LRI, Inc, USA). Image analysis was performed using
MCID basic 7.0 software (Imaging Research, USA). The location of the maximal lesion was
determined and serial sections used for compositional analysis, including picro-sirius staining
for the quantification of collagen content.

**Immunohistochemistry**
De-waxed and re-hydrated sections were blocked with goat serum before incubation with
primary antibodies to α-smooth muscle actin (1:400; 30 min; Sigma, UK) and Mac2 (1:6000;
onight; Cedarlane, USA). Sections were then washed and incubated with a secondary
antibody (goat anti-mouse or goat anti-rat, respectively; 1:400, 30 min; Vector Labs, UK).
This was followed by incubation with streptavidin-conjugated horseradish peroxidase
Extravidin; 30 min; Sigma, UK). Slides were developed by addition of 3,3-diaminobenzidine
(DAB peroxidase staining kit, Vector Lab, UK) for 1 min. Images were taken as before and
analysed with Image J software.

References

1. Bagnall AJ, Kelland NF, Gulliver-Sloan F, Davenport AP, Gray GA, Yanagisawa M,
Webb DJ, Kotelevtsev YV. Deletion of endothelial cell endothelin B receptors does not
affect blood pressure or sensitivity to salt. *Hypertension*. 2006;48:286-293.

Non-endothelial cell endothelin-B receptors limit neointima formation following vascular

Herz J, Kuhn M. Smooth muscle-selective deletion of guanylyl cyclase-A prevents the
acute but not chronic effects of ANP on blood pressure. *Proc Natl Acad Sci USA*

4. Davenport AP, Kuc RJ. Radioligand binding assays and quantitative autoradiography of

Maguire JJ, Davenport AP, Kotelevtsev YV, Webb DJ. Endothelial cell specific ETB


**Supplementary Table S1.** Deletion of ET\(_B\) from smooth muscle did not alter body or organ weights.

<table>
<thead>
<tr>
<th>Age &amp; Weights</th>
<th>Wild Type</th>
<th>SMET(_B) KO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (weeks)</td>
<td>20.0 ± 1.4</td>
<td>20.8 ± 1.6</td>
</tr>
<tr>
<td>Body Weight (g)</td>
<td>31.6 ± 0.8</td>
<td>32.1 ± 0.6</td>
</tr>
<tr>
<td>Heart (% Body Weight)</td>
<td>0.56 ± 0.03</td>
<td>0.56 ± 0.02</td>
</tr>
<tr>
<td>Liver (% Body Weight)</td>
<td>5.08 ± 0.15</td>
<td>4.88 ± 0.18</td>
</tr>
<tr>
<td>Right Kidney (% Body Weight)</td>
<td>0.72 ± 0.03</td>
<td>0.74 ± 0.03</td>
</tr>
<tr>
<td>Right Kidney (% Body Weight)</td>
<td>0.68 ± 0.02</td>
<td>0.71 ± 0.03</td>
</tr>
<tr>
<td>Lung (% Body Weight)</td>
<td>0.54 ± 0.03</td>
<td>0.56 ± 0.02</td>
</tr>
</tbody>
</table>

*Data are mean ± s.e. mean, n=7.*
**Supplementary Table S2.** Impact of endothelial cell removal on function of aorta and femoral arteries from control mice.

<table>
<thead>
<tr>
<th>Drug</th>
<th>Measurement</th>
<th>Aorta (Intact)</th>
<th>Aorta (Denuded)</th>
<th>Femoral Artery (Intact)</th>
<th>Femoral Artery (Denuded)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE</td>
<td>N</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>pD(_2)</td>
<td>7.1 ± 0.2</td>
<td>7.3 ± 0.2</td>
<td>5.8 ± 0.1</td>
<td>6.5 ± 0.1*</td>
</tr>
<tr>
<td></td>
<td>Emax (%)</td>
<td>80.3 ± 5.5</td>
<td>199.8 ± 11.4*</td>
<td>100.3 ± 6.2</td>
<td>94.6 ± 4.5</td>
</tr>
<tr>
<td></td>
<td>Emax (mN/mm)</td>
<td>3.92 ± 0.34</td>
<td>3.48 ± 0.19</td>
<td>2.35 ± 0.20</td>
<td>1.61 ± 0.14</td>
</tr>
<tr>
<td>ACh</td>
<td>N</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>-logIC(_{50})</td>
<td>7.4 ± 0.4</td>
<td>7.9 ± 1.0</td>
<td>7.4 ± 0.2</td>
<td>6.5 ± 6.1</td>
</tr>
<tr>
<td></td>
<td>Emax (%)</td>
<td>62.7 ± 7.1</td>
<td>31.5 ± 7.3</td>
<td>108.6 ± 5.7</td>
<td>19.5 ± 11.8*</td>
</tr>
<tr>
<td>ET-1</td>
<td>N</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>pD(_2)</td>
<td>8.5 ± 0.4</td>
<td>8.0 ± 0.2</td>
<td>8.2 ± 0.2</td>
<td>8.4 ± 0.1</td>
</tr>
<tr>
<td></td>
<td>Emax (%)</td>
<td>53.4 ± 8.4</td>
<td>74.3 ± 4.7</td>
<td>95.2 ± 4.5</td>
<td>89.6 ± 4.2</td>
</tr>
<tr>
<td></td>
<td>Emax (mN/mm)</td>
<td>1.78 ± 0.42</td>
<td>1.23 ± 0.20</td>
<td>2.51 ± 0.36</td>
<td>2.35 ± 0.46</td>
</tr>
<tr>
<td>KPSS</td>
<td>N</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Emax (mN/mm)</td>
<td>2.91 ± 0.58</td>
<td>2.03 ± 0.43</td>
<td>3.21 ± 1.36</td>
<td>2.56 ± 1.23</td>
</tr>
</tbody>
</table>

Data are mean±s.e. raw. ACh, acetylcholine; ET-1, endothelin-1; KPSS, high (125mM) potassium physiological salt solution. PE, phenylephrine. *P<0.05 compared with intact artery. Emax, maximum contraction; pD\(_2\), -log EC\(_{50}\).
**Supplementary Table S3** Impact of deletion of ET₉ from vascular smooth muscle on functional responses of femoral arteries.

<table>
<thead>
<tr>
<th>Drug</th>
<th>Measurement</th>
<th>Wild Type (Intact)</th>
<th>Wild Type (Denuded)</th>
<th>SM ET₉ KO (Intact)</th>
<th>SM ET₉ KO (Denuded)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE</td>
<td>N</td>
<td>6</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>pD₂</td>
<td>5.7 ± 0.1</td>
<td>6.0 ± 0.1</td>
<td>5.6 ± 0.1</td>
<td>6.1 ± 0.1</td>
</tr>
<tr>
<td></td>
<td>Emax(%)</td>
<td>88.9 ± 3.2</td>
<td>94.2 ± 3.2</td>
<td>91.9 ± 4.4</td>
<td>102.8 ± 3.8</td>
</tr>
<tr>
<td></td>
<td>Emax (mN/mm)</td>
<td>3.99 ± 0.35</td>
<td>2.05 ± 0.26</td>
<td>3.48 ± 0.25</td>
<td>2.37 ± 0.20</td>
</tr>
<tr>
<td>ACh</td>
<td>N</td>
<td>5</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>-logIC₅₀</td>
<td>8.0 ± 0.6</td>
<td>6.8 ± 0.4†</td>
<td>7.9 ± 0.5</td>
<td>7.2 ± 0.6*</td>
</tr>
<tr>
<td></td>
<td>Emax(%)</td>
<td>120.1 ± 1</td>
<td>57.8 ± 6.4*</td>
<td>120.9 ± 9.6</td>
<td>22.5 ± 3.2‡</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ET-1</td>
<td>N</td>
<td>6</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>pD₂</td>
<td>7.8 ± 0.2</td>
<td>7.8 ± 0.3</td>
<td>7.9 ± 0.2</td>
<td>8.0 ± 0.2</td>
</tr>
<tr>
<td></td>
<td>Emax(%)</td>
<td>97.4 ± 7.9</td>
<td>112.9 ± 3.5</td>
<td>105.4 ± 5.8</td>
<td>130.3 ± 5.4</td>
</tr>
<tr>
<td></td>
<td>Emax (mN/mm)</td>
<td>4.03 ± 0.42</td>
<td>2.46 ± 0.40</td>
<td>4.04 ± 0.33</td>
<td>2.99 ± 0.27</td>
</tr>
<tr>
<td>KPSS</td>
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<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Emax (mN/mm)</td>
<td>4.44 ± 0.81</td>
<td>1.99 ± 0.64*</td>
<td>3.84 ± 0.52</td>
<td>2.38 ± 0.54</td>
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</tbody>
</table>

Data are mean ± s.e.mean. SM ET₉ KO, selective deletion of the endothelin B receptor from smooth muscle. ACh, acetylcholine, ET-1, endothelin-1, KPSS, high (125mM) potassium physiological salt solution. PE, phenylephrine. *P<0.05, †P<0.01, ‡P<0.005 compared with intact artery. Emax, maximum contraction; pD₂, -log EC₅₀.
**Supplementary Table S4.** Impact of endothelin receptor antagonism on endothelin-1-mediated contraction of murine mesenteric arteries.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Vehicle</th>
<th>ET&lt;sub&gt;A&lt;/sub&gt;</th>
<th>ET&lt;sub&gt;B&lt;/sub&gt;</th>
<th>ET&lt;sub&gt;A/B&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>7</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>pD₂</td>
<td>8.2±0.5</td>
<td>7.4±0.2*</td>
<td>8.0±0.1</td>
<td>7.0±0.1*</td>
</tr>
<tr>
<td>Emax (mN/mm)</td>
<td>2.4±0.7</td>
<td>2.4±1.3</td>
<td>3.4±0.5</td>
<td>2.3±1.0</td>
</tr>
<tr>
<td>Emax (% KPSS)</td>
<td>105±17</td>
<td>102±21</td>
<td>111±10</td>
<td>75±30</td>
</tr>
</tbody>
</table>

Data are mean±s.e.mean. *P<0.05 compared with Vehicle. Emax, maximum contraction; pD₂, -log EC₅₀.
**Supplementary Table S5.** Incubation induces ET<sub>B</sub>-mediated contraction in mouse mesenteric arteries.

<table>
<thead>
<tr>
<th>Drug</th>
<th>Measurement</th>
<th>Day 0</th>
<th>Day 1</th>
<th>Day 5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>KPSS</strong></td>
<td>N</td>
<td>7</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Emax (mN/mm)</td>
<td>2.47±0.80</td>
<td>2.42±0.68</td>
<td>1.40±1.03</td>
<td></td>
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<tr>
<td><strong>PE</strong></td>
<td>N</td>
<td>7</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>pD&lt;sub&gt;2&lt;/sub&gt;</td>
<td>5.90±0.25</td>
<td>5.71±0.24</td>
<td>5.65±0.44</td>
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<tr>
<td>Emax (mN/mm)</td>
<td>2.33±0.70</td>
<td>2.89±1.30</td>
<td>1.04±1.24</td>
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<tr>
<td>Emax (% KPSS)</td>
<td>97.8±15.6</td>
<td>114.1±25.1</td>
<td>111.7±91.7</td>
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</tr>
<tr>
<td><strong>S6c</strong></td>
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<td>7</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>pD&lt;sub&gt;2&lt;/sub&gt;</td>
<td>---</td>
<td>8.75±0.19</td>
<td>8.73±0.05</td>
<td></td>
</tr>
<tr>
<td>Emax (mN/mm)</td>
<td>0.13±0.16</td>
<td>1.13±1.08*</td>
<td>0.82±0.60†</td>
<td></td>
</tr>
<tr>
<td>Emax (% KPSS)</td>
<td>6.4±7.6</td>
<td>40.2±32.6*</td>
<td>94.5±75.4†</td>
<td></td>
</tr>
<tr>
<td><strong>ET-1</strong></td>
<td>N</td>
<td>7</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>pD&lt;sub&gt;2&lt;/sub&gt;</td>
<td>8.24±0.53</td>
<td>8.50±0.40</td>
<td>8.54±0.25</td>
<td></td>
</tr>
<tr>
<td>Emax (mN/mm)</td>
<td>2.45±0.73</td>
<td>3.79±0.88*</td>
<td>1.35±1.22*</td>
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</tr>
<tr>
<td>Emax (% KPSS)</td>
<td>105.4±17.8</td>
<td>164.1±16.4*</td>
<td>132.8±87.6</td>
<td></td>
</tr>
</tbody>
</table>

Data are mean±s.e.mean. ET-1, endothelin-1; KPSS, high (125mM) potassium physiological salt solution; PE, phenylephrine; S6c, sarafotoxin s6c. *P<0.05 compared with Day 0. †P<0.05 compared with Day 1. Emax, maximum contraction; pD<sub>2</sub>, -log EC<sub>50</sub>. 
Supplementary Table S6. Impact of endothelin receptor antagonism on sarafotoxin s6c-mediated contraction of murine mesenteric arteries.

<table>
<thead>
<tr>
<th>Timepoint</th>
<th>Measurement</th>
<th>Vehicle</th>
<th>ET&lt;sub&gt;A&lt;/sub&gt;</th>
<th>ET&lt;sub&gt;B&lt;/sub&gt;</th>
<th>ET&lt;sub&gt;A/B&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 0</td>
<td>N</td>
<td>7</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>pD&lt;sub&gt;2&lt;/sub&gt;</td>
<td>NC</td>
<td>NC</td>
<td>NC</td>
<td>NC</td>
</tr>
<tr>
<td></td>
<td>Emax (mN/mm)</td>
<td>0.13±0.16</td>
<td>0.01±0.01</td>
<td>0.03±0.03</td>
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</tr>
<tr>
<td></td>
<td>Emax (% KPSS)</td>
<td>6.4±7.6</td>
<td>0.90±1.3</td>
<td>1.0±06</td>
<td>1.2±1.2</td>
</tr>
<tr>
<td>Day 1</td>
<td>N</td>
<td>7</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>pD&lt;sub&gt;2&lt;/sub&gt;</td>
<td>8.75±0.19</td>
<td>8.41±0.17*</td>
<td>NC</td>
<td>NC</td>
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<tr>
<td></td>
<td>Emax (mN/mm)</td>
<td>1.13±1.08</td>
<td>2.63±0.90</td>
<td>0.01±0.01</td>
<td>0.00±0.01</td>
</tr>
<tr>
<td></td>
<td>Emax (% KPSS)</td>
<td>40.2±32.6</td>
<td>73.3±17.75</td>
<td>0.7±0.4*</td>
<td>0.4±0.4*</td>
</tr>
</tbody>
</table>

Day 0, fresh arteries; Day 1, 24 h incubation. Data are mean±s.e.mean. NC, not calculated.
*P<0.05 compared with Vehicle. Emax, maximum contraction; pD<sub>2</sub>, -log EC<sub>50</sub>. 
**Supplementary Table S7.** The impact of vascular cell selective deletion of murine vascular ET$_B$ receptors (compared with wild type controls).

<table>
<thead>
<tr>
<th>Measurement</th>
<th>EC ET$_B$ KO*</th>
<th>SMC ET$_B$ KO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body Weight</td>
<td>NSD$^{1,2,3,4}$</td>
<td>NSD</td>
</tr>
<tr>
<td>Organ Weight</td>
<td>NSD$^{1,2,4}$</td>
<td>NSD</td>
</tr>
<tr>
<td>Plasma [ET-1]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basal</td>
<td>Increased$^2$</td>
<td>NSD</td>
</tr>
<tr>
<td>High salt diet + ET$_B$ antagonist</td>
<td>NSD</td>
<td>NSD</td>
</tr>
<tr>
<td>Blood Pressure (basal)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basal</td>
<td>NSD$^2$</td>
<td>Small (4mmHg) Increase</td>
</tr>
<tr>
<td>High salt diet</td>
<td>NSD$^2$</td>
<td>Small (4mmHg) Increase</td>
</tr>
<tr>
<td>High salt diet + ET$_B$ antagonist</td>
<td>NSD$^2$</td>
<td>NSD</td>
</tr>
<tr>
<td>Heart Rate</td>
<td>NSD$^2$</td>
<td>Reduced</td>
</tr>
<tr>
<td>Neointimal Proliferation</td>
<td>NSD$^{1,4}$</td>
<td>NSD</td>
</tr>
<tr>
<td>ET$_B$-mediated contraction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trachea</td>
<td>NSD$^{1,2,4}$</td>
<td>Reduced</td>
</tr>
<tr>
<td>Mesenteric Vein</td>
<td>N/A</td>
<td>Abolished</td>
</tr>
<tr>
<td>Mesenteric Artery</td>
<td>N/A</td>
<td>Induction Abolished</td>
</tr>
<tr>
<td>Femoral Artery</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>ACh-mediated relaxation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aorta</td>
<td>Impaired$^2$</td>
<td>NSD</td>
</tr>
<tr>
<td>Femoral Artery</td>
<td>NSD$^{1,4}$</td>
<td>NSD</td>
</tr>
<tr>
<td>ET-1-mediated contraction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Femoral Artery</td>
<td>NSD$^{1,4}$</td>
<td>NSD</td>
</tr>
<tr>
<td>PE-mediated contraction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Femoral Artery</td>
<td>NSD$^{1,4}$</td>
<td>NSD</td>
</tr>
</tbody>
</table>

From previous investigations. $^1$Kirkby et al., 2012; $^2$Bagnall et al., 2006; $^3$Kelland et al., 2010; $^4$Kirkby, N.S. PhD Thesis Edinburgh 2009. ACh, acetylcholine; ET-1, endothelin-1; PE, phenylephrine; ET$_B$, endothelin B receptor; NSD, No significant difference compared with Wild Type; N/A, not assessed.
Supplementary Figure S1. Identification of smooth muscle, macrophages and collagen in neointimal lesions.

Compositional analysis of neointimal lesions induced by wire injury in smooth muscle selective ET$_B$ KO (SMET$_B$KO) and wild type mouse femoral arteries showing the presence of immunoreactivity for (a) Smooth muscle actin (brown) and (b) Macrophages (Mac 2; brown). (c) Picrosirius red staining (pink) identified collagen in the neointima and media. Scale bar = 100μm. L, Lumen, NI, neointima.

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Supplementary Figure S2. Impact of endothelial cell removal on functional responses of murine aorta and femoral artery.

Aorta (a, b, c) and femoral arteries (d, e, f) from adult male C57Bl/6j mice relaxed in response to acetylcholine (ACh) (a, d) and contracted in response to phenylephrine (PE) (b, e) and endothelin-1 (ET-1) (c, f). Removal of the endothelium abolished ACh-mediated relaxation and substantially increased aortic, but not femoral arterial, contraction to PE. It did not, however, alter ET-1 mediated contraction in aorta or in femoral artery. Symbols represent mean+s.e.mean for n=3 mice. *P<0.05; **P<0.01; ***P<0.001.

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Supplementary Figure S3. Selective deletion of ET_b from the smooth muscle does not alter femoral artery function.

Concentration-response curves for (a) phenylephrine (PE), (b) endothein-1 (ET-1) and (c) acetylcholine (ACh) were generated in femoral arteries from control (FF--) and SM ET_b knockout (FFSm22Cre) mice. Responses to ACh were obtained following sub-maximal contraction with PE. Deletion of ET_b had no effect on the responses produced by these agonists. Symbols represent mean±s.e.mean for n=6-7mice.

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Supplementary Figure S4. Endothelin-1-mediated contraction of murine mesenteric arteries is mediated by $\text{ET}_A$ receptors.

In murine mesenteric arteries endothelin-1 (ET-1)-mediated contraction was shifted dramatically to the right by incubation with selective $\text{ET}_A$ (BQ123; 100nM) or mixed $\text{ET}_{A/B}$ antagonism, but selective $\text{ET}_B$ antagonism (A-192621; 100nM) had a much smaller effect. Symbols represent mean±s.e.mean, n=3-7. *P<0.05 compared with Vehicle.

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Supplementary Figure S5. Neointimal lesion formation does not alter functional responses of mouse femoral artery.

Mouse femoral arteries isolated 28 days after ligation showed unaltered responses to (a) phenylephrine (PE), (b) acetylcholine (ACh) or, (c) sodium nitroprusside (SNP). Data are mean±s.e.mean, n=3-6.
Supplementary Figure S6. Schematic summary of the effects of smooth muscle cell specific deletion of the Endothelin B receptor (SM ET$_B$ KO) in mice.

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